



## **MINI - MONITOR**

**Models 900 'R' 'G' & 'D'**

**Series 900 Radiation Monitors**

# **MANUAL**

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 **Morgan**  
ELECTRONICS DIVISION

**MINI-INSTRUMENTS LIMITED**

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**Models 900 'R' 'G' & 'D'**

**Series 900 Radiation Monitors**

Our instruments are subject to continuous development and minor changes in detail may occur which are not incorporated in this manual.

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# 1. GENERAL DESCRIPTION

## 1.1 Basic monitor

The monitor is designed for use in teaching, research, hospital, industrial laboratories and other areas where radiation levels need to be measured down to the accepted levels of safety.

The monitor is powered by easily available primary cells or may be mains operated from a small power unit. In addition rechargeable cells can be used which are recharged by using the same power unit.

The probe is connected to the monitor by a coiled extensible cable. It may be used remotely or attached to the case by a clip. A meter registers the intensity on a semi-logarithmic scale thus making range changing unnecessary. An internal speaker, which may be switched off, gives an audible indication of intensity.

The monitor has a warning alarm adjustable to trip at any selected level on the scale. It can be made inoperative during normal use but will respond on overload.

## 1.2 Probe attachments

The monitor is available with three different probes, each identified as a separate model. The probes cannot be exchanged as the meter is uniquely scaled for the probe.

- (a) **Model R** This model is scaled 0.5 to  $5000\mu\text{Sv h}^{-1}$ . The G-M tube is compensated to give a useful response from 45keV to 1.25MeV and above. The tube has a response nearly independent of orientation but the most reliable measurements are made with the incidence of radiation normal to the axis of the tube.
- (b) **Model G** This model is scaled 0.05 to  $75\mu\text{Sv h}^{-1}$ . The G-M tube is compensated to give a useful response from 55keV to 1.25MeV with the radiation normal to the axis of the tube.

- (c) **Model D** Is scaled 0.1 to  $1000 \mu\text{Sv h}^{-1}$ . The G-M tube is partially compensated to give a response from 30keV to 1.25MeV. The detector is directional, particularly at low energies, and must therefore only be used where the radiation is incident on the front face of the detector.

The probe may be used further from the instrument than allowed by the extensible cable. Up to 15 metres of low capacity coaxial cable is acceptable.

G.M. Tube	$\gamma$ -sensitivity (CS137):
	<u><math>1 \mu\text{SV/hr } \gamma</math></u>
Type D probe:	2.2 c/s
Type R probe:	0.95 c/s
Type <u>G/GL</u> probes:	16.9 c/s
(see: <u>page 16</u> )	

## **2. OPERATING INSTRUCTIONS**

### **2.1 Controls**

There are two external controls:-

- (a) A four position rotary switch labelled with symbols OFF, BAT, ON, ON (SPEAKER OFF).
- (b) A screwdriver control to set alarm level.

### **2.2 Battery**

The state of the battery is indicated on the meter when the switch is turned to the position marked "bat". In this position the battery is subjected to a current drain in excess of that used in normal operation. In order to ensure that the battery is satisfactory the pointer should be observed for about 15-20 seconds to see if it falls below the green sector. If so the battery should be changed or if rechargeable, put on charge.

The battery is contained within the rear compartment. A half turn on the screw lets down the flap to reveal the six cells contained in a removable holder. Take out the holder and replace the cells observing the correct polarity. The label on the hinged flap suggests some suitable replacement types. Make sure the monitor is off before connecting the press studs as an accidental reversal may damage the circuit.

### **2.3 Mains operation**

The monitor may be operated from the mains by using a separate power unit. For electrical safety reasons it **MUST** use a "DOUBLE INSULATED" isolating transformer. The unit supplied by Mini-Instruments Ltd is recommended as it conforms to the appropriate specifications. The same unit also provides the charging current when rechargeable cells are fitted.

The unit is plugged into the jack socket situated on the right-hand side of the case. A green LED shows when in use. When the power unit is plugged in, the internal batteries are disconnected but make sure that the internal charge switch is "off" if the cells are *not* rechargeable.

Mains units are available for the following supplies:-

210 – 250 V, 50Hz and 110 – 120 V, 60Hz

Output 12 – 18 volts d.c. at 75 mA

There is no internal fuse in the monitor. Should a failure occur that overloads the mains power unit a thermal protection device cuts off the mains input. The thermal device is not resettable.

## **2.4 Battery charge**

The mains unit can be used to replenish rechargeable cells. When the cells are exhausted plug in the mains unit and switch the charge switch within the battery compartment over to "charge". The charge rate is 45mA and charging is complete in 16 h. Do NOT charge primary cells. When the charge is complete switch off the charger at the mains.

## **2.5 Setting the alarm**

The alarm level is variable from zero to beyond the limit of the scale. It is set by using a test source to give the desired level and adjusting the front panel control with a small screwdriver. The alarm resets when the radiation level falls below the trip level. If the control is turned fully clockwise the alarm is disabled for all levels on the scale. The alarm is not disabled for overload conditions providing this adjustment is correctly made: see section 5.5. In addition the alarm is not switched out by the "speaker off" position.

### 3. RESPONSE TO RADIATION

The monitors are calibrated against exposure using a  $^{137}\text{Cs}$  source traceable to national standards. Tests are made at four points on the scale plus overload to satisfy UK recommendations and to check compliance with IEC document 395. For practical reasons these tests are carried out on the basis that 1 Sievert equals 100 Roentgens exposure.

You are strongly advised to have the monitor response checked at least yearly. This can be carried out by the company.

#### 3.1 Model R

The G-M tube is mounted, together with its compensating shields, in a thin walled aluminium tube. The sensitive length is 20mm.

Figure 1 shows the relative energy response of a sample tube.

Figure 2 shows the polar response at 60keV. The response improves at higher energies.

A paralysis time of  $50\mu\text{s}$  is included in the scaling of the meter. The correction does not exceed 25% at full scale.

**Response to other ionising radiation** The monitor detects radiations other than X and  $\gamma$  rays. The response quoted below is defined as scale reading divided by true equivalent dose rate.

Soft $\beta$	negligible
Hard $\beta$	0.02
Neutrons ( $^{241}\text{Am/Be}$ )	0.03

**Response time** This is the time taken for the meter to indicate 63% of a sudden tenfold change in radiation level.

Doserate change	Response time
1-10	8s
10-100	3s
100-1000	1.5s

**Transport index** To assist in the use of this instrument for measurement of packets and containers in transport the transport index (TI) at 1 metre is marked on the scale below the "replace battery" sector.

### 3.2 Model G

The G-M tube is nearly 20 times more sensitive than the type "R" tube and is energy compensated for radiation normal to the axis. In practice, a tilt of  $+45^\circ$  makes only a small percentage difference to the reading.

Figure 3 shows the relative energy response of a sample tube.

Owing to the large size of the tube care should be taken in the interpretation of measurements made in divergent radiation. Point sources should not be brought closer than one metre to the axis to keep errors below 5%.

The scale has been corrected to compensate for a paralysis time of  $200\mu\text{s}$ .

**Response to other ionising radiation** The monitor detects radiations other than X and  $\gamma$  rays. The response quoted below is defined as scale reading divided by true equivalent dose rate.

Soft $\beta$	negligible
Hard $\beta$	0.001
Neutrons (4-5MeV)	<0.01

**Response time** This is the time taken for the meter to indicate 63% of a sudden tenfold change in radiation level.

Doserate change	Response time
0.1-1	12s
1-10	2s
10-100	.5s

**Internal background** The 900G tube has an internal background count of approximately  $0.46\text{counts s}^{-1}$ . The special 900GL tube has a background of approximately  $0.18\text{counts s}^{-1}$ . These correspond to  $0.033\mu\text{Sv h}^{-1}$  and  $0.013\mu\text{Sv h}^{-1}$  respectively. This should be taken into account when measuring low background rates.

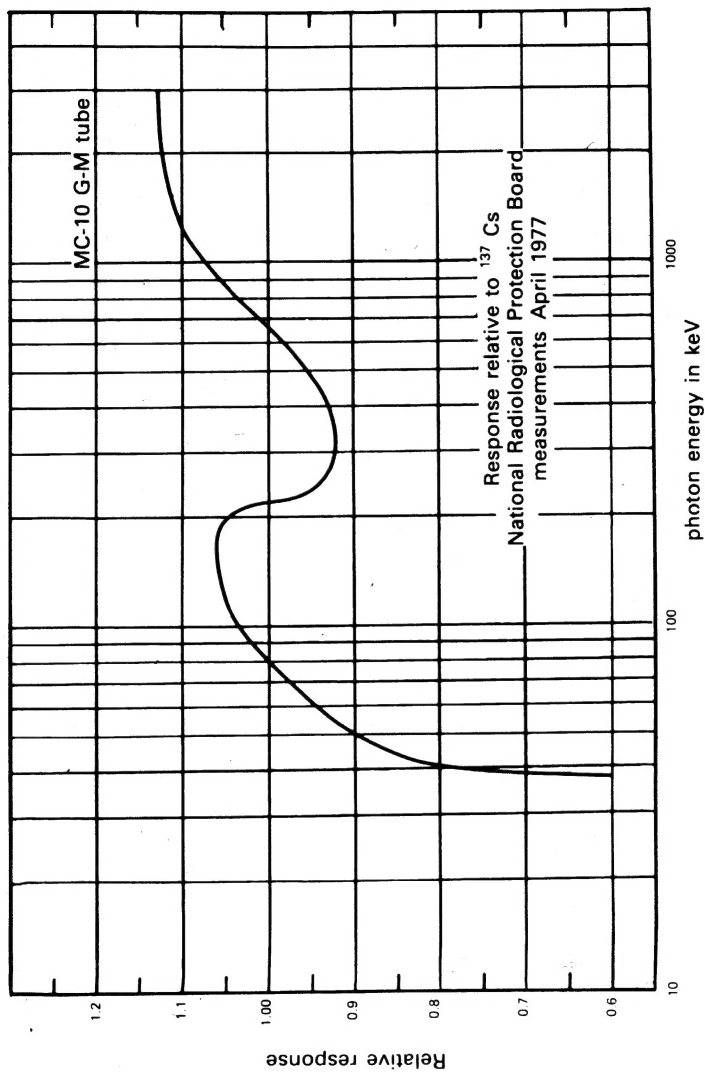


Fig. 1 Relative response of the model R dose rate meter.

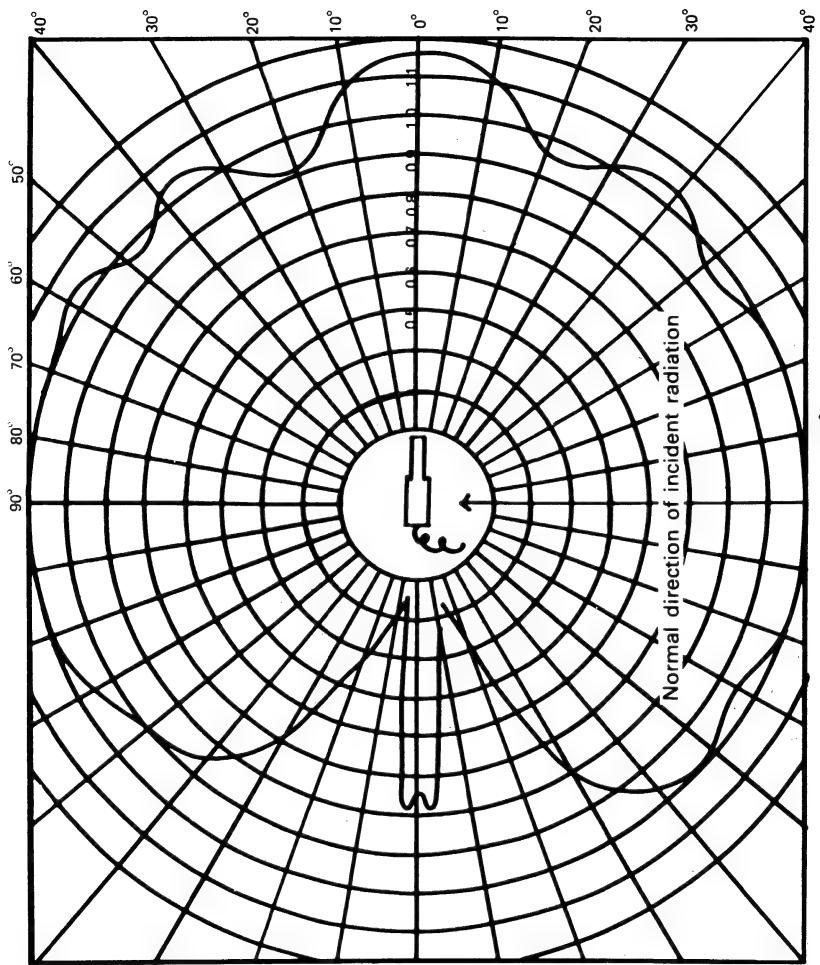


Fig. 2 Polar response of the model R dose rate meter to 60 keV  $^{241}\text{Am}$   $\gamma$  rays  
Curve derived from National Radiological Protection Board measurements April 1977

### 3.3 Model D

The instrument is scaled from 0.1 to  $1000\mu\text{Sv h}^{-1}$ . It uses a  $\gamma$  compensated end window G-M tube where the energy compensation is provided by a combination of copper, tin and plastic filters. The thin window is only partially obscured by the filters, a feature which enables the 900 'D' to maintain a useful response down to at least 30keV.

Figure 4 shows the photon energy response of the G-M tube. The response is normalised to 0.662 MeV ( $^{137}\text{Cs}$ ) and has a range of 30keV to 1.25 MeV +20% / -12%. This response was obtained with the radiation flux incident on the front face of the probe in the axial plane of the G-M tube. This is the normal operating position for making measurements.

The monitor has an internal paralysis time of  $75\mu\text{s}$  giving a counting loss of less than 20% at  $1000\mu\text{Sv h}^{-1}$ . No correction need be applied as the meter scaling includes a correction.

#### Directional response

The directional (polar) response is summarised below.

E(keV)	Maximum deviation from normal incidence over first $45^\circ$
65	+7% to -12%
100	+2% to - 6%
161	0% to - 9%
662	0% to -10%

At lower energies the variations in directional response will be greater. To reduce the error always try to point the probe directly at the source of radiation.

**Response to other ionising radiation** The monitor detects radiations other than X and  $\gamma$  rays. The response quoted below (with the cap off) is defined as scale reading divided by true equivalent dose rate.

$^{90}\text{Sr}/^{90}\text{Y } \beta$	0.8
Neutrons ( $^{241}\text{Am}/\text{Be}$ )	0.03

A substantial part of the G-M tube window (superficial density 1.5-2.0 mg cm<sup>-2</sup>) is *not* covered by the  $\gamma$  compensating filters. The monitor will therefore respond to  $\beta$  radiation of 150keV and above. Care should be taken when interpreting the monitor readings in the presence of poorly shielded  $\beta$  sources. Where  $\gamma$  and  $\beta$  radiation are present together the monitor will generally overestimate the dose rate.

**Response time** This is the time taken for the meter to indicate 63% of a sudden tenfold change in radiation level.

Doserate change	Response time
1-10	3.5s
10-100	2s
100-1000	1s

OTHER PROBES :

**Response to 1mR./hour <sup>60</sup>Co $\gamma$  radiation**

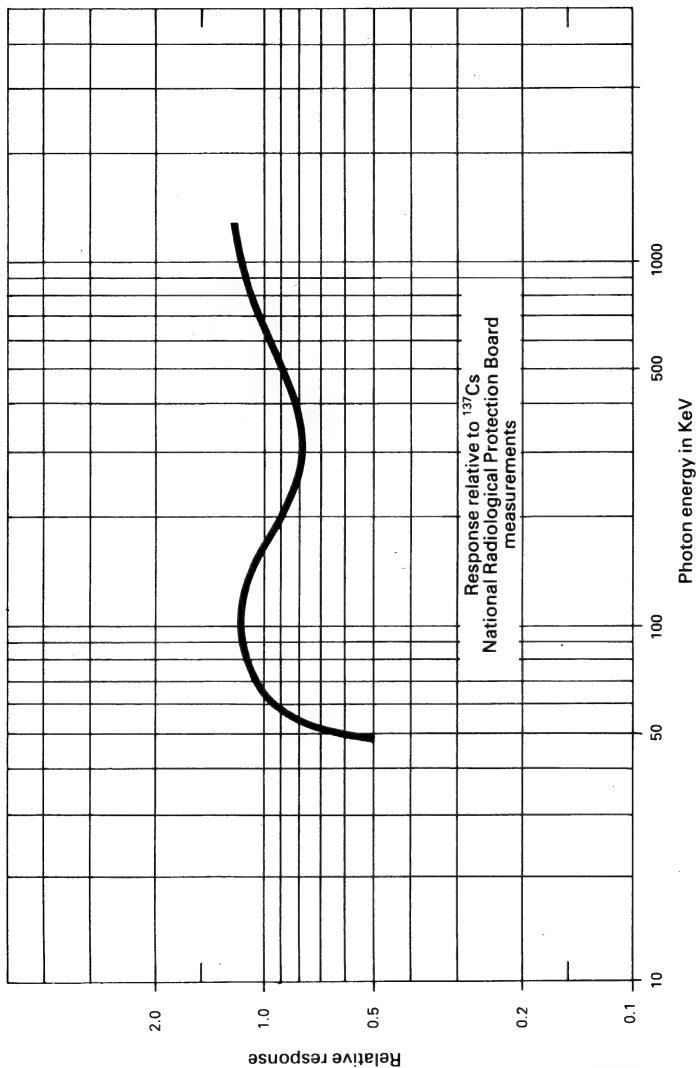
(10 $\mu$ Sv/hr)	G-M tube	approx. c/s
S (SIDE WINDOW)	B6H	55
- E (END WINDOW)	MX 123	40
X (X-RAY)	MX 168 MX 180	25

**contamination measurements**

Y-90 / SR-90 ( $\beta$ )<sub>r</sub>

Model S		Model E without protective grille (x 0.6 with grille)			
5 cm from surface		5 cm from surface		close to surface	
10 <sup>-4</sup> $\mu$ Ci/cm <sup>2</sup>	10 <sup>-3</sup> $\mu$ Ci/cm <sup>2</sup>	10 <sup>-4</sup> $\mu$ Ci/cm <sup>2</sup>	10 <sup>-3</sup> $\mu$ Ci/cm <sup>2</sup>	10 <sup>-4</sup> $\mu$ Ci/cm <sup>2</sup>	10 <sup>-3</sup> $\mu$ Ci/cm <sup>2</sup>
4	35	3-4	30	6	55

27CM-LONG MX145 GIGER TUBE  
(ZP1220/LND78017; 200 $\mu$ s dead time)



MODEL G : MC70 PROBE WITH MX145 TUBE

Fig. 3 Relative response of the model G dose rate meter.

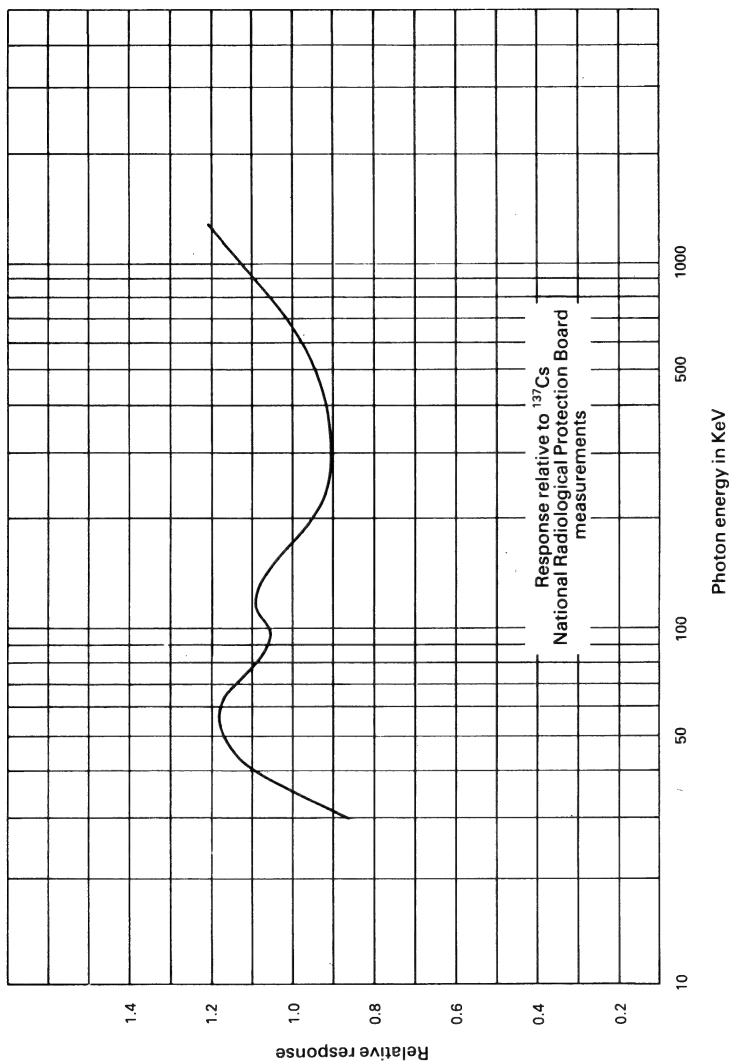


Fig. 4 Relative response of the model D dose rate meter.

#### 4. PRECAUTIONS IN USING RADIATION METERS

The company believes it has taken all reasonable precautions to ensure that the correct use of these monitors does not endanger the health and safety of any person but it is essential that persons using these monitors should be trained to interpret the results sensibly and be aware of their limitations.

To help the operator some of these limitations are described below:-

- (a) Make sure that the battery is in good order. Do not perform the battery check too hastily or it will not give a true indication of battery condition.
- (b) Make sure that the monitor is working by noting if it is responding to background. It is sensible to check the monitor with a radioactive source to see if it is giving the expected reading and audible signal. The test source need not be traceable but a consistent source-to-tube geometry should be maintained.
- (c) The probe determines the performance of the monitor. Make sure the correct probe is chosen for the radiation you wish to monitor. Remember that the 'R' and 'G' monitors have a sharp cut off below about 50keV and should not be used to measure soft X-rays from low voltage equipment.
- (d) Some X-ray machines and particle accelerators produce radiation in short pulses. If the intensity of the radiation in these pulses is sufficient to cause a response at a rate exceeding an order of magnitude less than the pulse repetition frequency then non-linearity of response will occur. At the limit the monitor indicates pulse repetition frequency and not the radiation intensity.
- (e) Owing to the nature of the tube construction a pencil beam does not give a true reading. **The entire probe must be within a flux of constant intensity.**
- (f) The monitors are **not** suitable for the measurement of contamination or  $\beta$  dose rate.

- (g) The meter reading of G-M tube monitors is prone to fall back at very high radiation levels. This monitor contains an overload circuit to maintain full meter reading but its operation depends upon correct adjustment of an internal control. Users should occasionally check that full scale is maintained at high radiation levels. Do not try to estimate a reading off scale.
- (h) The monitor is not intrinsically safe and must not be used in potentially explosive atmospheres.
- (i) All probes are fragile. If you drop the probe it may not work again.
- (j) The monitor is not ruggedised and will not work if dropped into a pond or run over by a bus!

$\gamma$ -Dose rate from " $x$ " MBq  
emitting " $E$ "  $\gamma$ -MeV per decay,  
at distance " $r$ " metres

$$= \frac{x E}{6 r^2} \mu\text{Sv/hr } (\gamma)$$

EG.:

For Co-60:  $E = 1.17 + 1.33$   
 $= 2.5$  MeV, so at

1 metre from 1 MBq ( $27 \mu\text{Ci}$ )  
the dose rate equivalent is

$$\frac{1 \times 2.5}{6 \times 1^2} = 0.417 \mu\text{Sv/hr.}$$

(useful for calibrating dose rate meters.)

## **5. MAINTENANCE**

The instructions that follow are written to help owners make certain repairs themselves. An expertise beyond that necessary to operate the monitor may be required and the company cannot be responsible for damage incurred to monitors or persons while carrying out these instructions. If there is doubt the monitor should be returned to the manufacturer.

If the monitor fails after having checked the battery then access to the components and pre-set controls is obtained by removing the front panel.

The components are mounted on a printed circuit board attached to the meter and switch.

### **5.1 G-M tube replacement**

The model 'G' probe is a sealed assembly and repair is only possible after returning it to the factory. The G-M tube in the 'R' and 'D' models may be replaced by the user. Both need a special tool to remove the circlip (Anderton type HD2) but long nosed pliers will do. On the model 'R' make a note of how the connections are made to the pins on the tube base as a reversal will damage the tube.

For the model 'D' remove the circlip from the probe housing using a suitable tool. Withdraw the G-M tube/spring assembly and disconnect the anode and cathode leads. The anode clip can be simply pulled off but the cathode lead has to be unwrapped from the spring. When re-connecting the cathode lead use plastic insulating tape to secure it in place. During replacement operations it is a good idea to keep the protective transit cap on the tube.

If the discarded tube is identical to the replacement tube then it is likely that none of the internal controls will require adjustment. However, you may be statutorily required to check the response. In particular you must ensure that the overload control is correctly set. See 5.5.

5.2 Meter zero adjustment

The mechanical zero set is on the meter barrel and any adjustment must be made with the monitor switched off. The pointer must rest at approximately 1mm below the scale zero. With the monitor switched on the electrical zero control VR3 is now adjusted to bring the pointer back to the scale zero. Owing to background radiation it must be adjusted with the tube disconnected. Allow several minutes for the meter to settle before making the adjustment.

5.3 Meter calibration

The calibration potentiometer VR4 is situated at the bottom centre of the printed circuit board. To recalibrate inject square pulses of a few volts via a 100 pF (2kV) capacitor into the G-M tube input pin. The pulse repetition rate will need to be corrected to allow for the paralysis time correction built into the scale. The table below relates the scale with the pulse repetition frequency (PRF).

This correction is shown in the table below:

Model R		Model G/GL	
Scale reading	PRF	Scale reading	PRF
$\mu\text{Sv h}^{-1}$		$\mu\text{Sv h}^{-1}$	
5000	3838	75	1016
2000	1735	50	727
1000	907	10	164
100	94.6	1	16.9
10	9.5	0.1	1.7

Model D		MODEL S, E, SL, X		MODEL EPS & EL	
Scale reading	PRF	Scale reading	PRF	Scale reading	PRF
$\mu\text{Sv h}^{-1}$					
1000	1925	2000	1667	500	435
500	1037	1000	909	200	189
100	221	500	476	100	97
50	112	200	196	50	49
10	22	100	99	10	10
		50	50		
		10	10		

PRF = 
$$\frac{\text{Scale reading}}{1 + \left[ \left( \frac{\text{scale reading}}{\text{reading}} \right) \times \left( \frac{\tau_{\text{pulse}}}{\text{lead time}} \right) \right]}$$

## **5.4 HV supply**

The detector HV supply can be varied from approximately 300 to 650 volts. The control for adjusting the HV is VR1. Clockwise rotation increases the potential. The voltage is best measured using a high resistance meter, at least 20kohm/V, connected between the junction of D3/C7 and OV. If a 20kohm/V meter is used the reading is approximately 25 volts down owing to meter loading. The required operating voltage is 450V for the model 'G' and 550V for models 'R' and 'D'.

## **5.5 Overload setting**

An overload circuit ensures that the meter pointer remains over maximum deflection for radiation intensities exceeding many times the maximum scale reading. The adjustment depends on the HV setting and G-M tube and must be done whenever either is changed. The control for setting the overload alarm point is the potentiometer VR2.

To adjust the alarm set the function switch to the 'speaker off' position and turn the control fully clockwise. Using a strong source send the meter well over the maximum scale mark, adjust the control to sound the alarm. Check that the alarm stops sounding when the source is moved to a position where the reading is equal to the maximum scale mark on the meter. If necessary re-adjust the control until this condition is met. In case of difficulty the company should be consulted.

## **6. SERVICE AND GUARANTEE**

With normal care and attention this monitor should give many years of service without attention.

If any fault occurs to the monitor within two years of purchase (one year for the G-M tube) that is due, in our opinion, to a manufacturing error then it will be repaired or replaced without charge.

If a fault occurs outside the guarantee period the company or its agents will service the equipment. A note explaining what you believe to be wrong is often helpful. If the customer wishes to repair the fault himself the company will give technical help. However the company does not wish to abrogate its prime responsibility to its customer to third parties and service organisations. If these organisations are employed they should be instructed to return the equipment, untampered, to us for service or repair. **OVERSEAS CUSTOMERS SHOULD RETURN INSTRUMENTS BY AIR PARCEL POST, NOT AIR FREIGHT.**

The company will not be responsible for damage or loss occurring in transit to the company whether or not properly packed but emphasis cannot be made strongly enough on the need to ensure adequate packing before returning for servicing.

The address is:

Service Department,  
Mini-Instruments Ltd.,  
8 Station Industrial Estate,  
Burnham on Crouch,  
Essex CM0 8RN  
Tel: Maldon (Essex) (0621) 783282  
Fax: Maldon (Essex) (0621) 783132  
Telex: 995445

## 7. CIRCUIT DESCRIPTION

The circuit diagram is given at the end of the manual. The circuit operation is as follows:-

- (a) **Battery input stabilising circuit** The line voltage of the monitor is  $5.8 \pm 0.2$  volts and is set by the reference diode RD.  $J_{1/2}$  is the comparator coupled to  $J_3$  and the series control  $J_4$ .
- (b) **Oscillator** Transistor  $J_6$  coupled to the transformer  $T_1$  forms the oscillator circuit.  $L_2$  supplies the necessary feedback to maintain oscillation. The amplitude of the oscillation is limited by the diode  $D_2$  whose potential is set by  $VR_1$ . The waveform across the tertiary winding  $L_3$  is half wave rectified to provide the G-M tube voltage.
- (c) **Input amplifier**  $J_9$  is an amplifier with a gain determined by feedback. It reverses the phase of the input pulse and supplies a positive signal to the CMOS monostable coupled gates which determines the paralysis time. The input requires negative pulses exceeding 100 mV into approximately 3000 ohms.
- (d) **Ratemeter circuit** Two analogue outputs are combined to give a signal nearly proportional to the log of the input pulse rate. This output is applied to an operational amplifier which drives the meter. The potentiometer  $VR_4$  sets the meter scale and  $VR_3$  the meter zero.
- (e) **Audio output** The speaker derives its power from a timer IC which produces a  $300\mu s$  pulse when triggered by the monostable. This connection is switched at the front panel to suppress the pulse output. A similar but unswitched connection from the comparator sets off the timer to give the alarm.
- (f) **Comparator** The comparator compares the potential on the set alarm control with an output from the meter amplifier. If the latter is greater the comparator trips and sets off the timer. A little hysteresis is applied to smooth out the random nature of the input.
- (g) **Overscale circuit** Excess current drawn through the probe when in a radiation flux exceeding many times the scale limit causes  $J_{7/8}$  to conduct thus maintaining the deflection of the meter. The potentiometer  $VR_2$  sets the limit when this occurs.

## 8 SPECIFICATION

Case size	165mm high, 180mm wide, 110mm deep
Weight	1.0kg
Material	Coated aluminium
Battery (6 cells)	Normal AA cells IEC type R6 Alkaline cells IEC type LR6 Rechargeable cells IEC KR15/51
Battery life (at 4h/day)	Normal cells – 150 hours Alkaline cells – 300 hours
HV supply	approx., 300-650V at 50 $\mu$ A max
Response time	See section 3.
Accuracy	IEC 395 Class 2
Linearity	$\pm 10\%$ over first 75% of scale
Meter	Taut band 0.5mA full scale over 65mm
Ambient temperature	-10 to +40 deg. Celsius
Relative humidity	Up to 85% non-condensing
Detector type	Halogen-quenched G-M tube.

### Model dependent characteristics

	R	G	D
Measurement range	0.5-5000	0.05-75	0.1-1000 $\mu$ Sv h <sup>-1</sup>
Energy range	45keV-1.25MeV	55keV-1.25MeV	30keV-1.25MeV
Gamma analysis time ( $\mu$ S)	55	180	75
Coefficient of variation, 10% at:	7	0.5	2.5 $\mu$ Sv h <sup>-1</sup>
<u>Sensitivity in counts s<sup>-1</sup>/<math>\mu</math>Sv h<sup>-1</sup></u> <u>(<sup>137</sup>Cs)</u>	<u>0.95</u>	<u>14</u>	<u>2.2</u>

## 9. COMPONENT LIST AND CIRCUIT DIAGRAM

Integrated circuits LM317, 4001, 4013, 4066, LM392, CM555

Reference diode RD ICL8069

Zener diode Z BZX83 C9V1

Transistors J<sub>1</sub>, J<sub>2</sub>, J<sub>10</sub> BC548B  
J<sub>3</sub>, J<sub>5</sub>, J<sub>7</sub>, J<sub>8</sub>, J<sub>9</sub> BC558  
J<sub>4</sub> BC328  
J<sub>6</sub> BC338

Diodes D<sub>1</sub> 1N4001  
D<sub>2</sub>, D<sub>5</sub>, D<sub>6</sub>, D<sub>7</sub>, D<sub>8</sub> 1N4148  
D<sub>3</sub>, D<sub>4</sub> GEA6  
LED IMO 5120

Resistors All metal film ½ watt 1% unless otherwise stated.

R <sub>1</sub>	330R		R <sub>22</sub>	39K
R <sub>2</sub>	27R		R <sub>23</sub>	10K
R <sub>3</sub>	390R	1W	R <sub>25</sub>	See table below
R <sub>4</sub>	15K		R <sub>26</sub>	1M
R <sub>5</sub>	6K8		R <sub>27</sub>	1M
R <sub>6</sub>	10K		R <sub>28</sub>	180R
R <sub>7</sub>	82K		R <sub>29</sub>	10K
R <sub>8</sub>	22K		R <sub>30</sub>	180R
R <sub>9</sub>	10K		R <sub>31</sub>	100K
R <sub>10</sub>	4K7		R <sub>32</sub>	10K
R <sub>11</sub>	10K		R <sub>33</sub>	22K
R <sub>12</sub>	470R		R <sub>34</sub>	680R
R <sub>13</sub>	2K7		R <sub>35</sub>	150K
R <sub>14</sub>	4K7		R <sub>36</sub>	10K
R <sub>15</sub>	100K		R <sub>37</sub>	4M7
R <sub>16</sub>	1M (+ See over)		R <sub>38</sub>	47K
R <sub>17</sub>	3K3		R <sub>39</sub>	100K
R <sub>18</sub>	150K		R <sub>40</sub>	10K
R <sub>19</sub>	220K		R <sub>41</sub>	120K
R <sub>20</sub>	6K8		R <sub>42</sub>	G-M tube current limiter (in probe)
R <sub>21</sub>	330K			
VR <sub>1</sub>	22K		VR <sub>4</sub>	50R
VR <sub>2</sub>	100K		VR <sub>5</sub>	22K
VR <sub>3</sub>	100K			

→ R<sub>16</sub> is 100KΩ for Scintillation probe!

→ VR<sub>2</sub> ← 220KΩ for Scintillation

## Capacitors

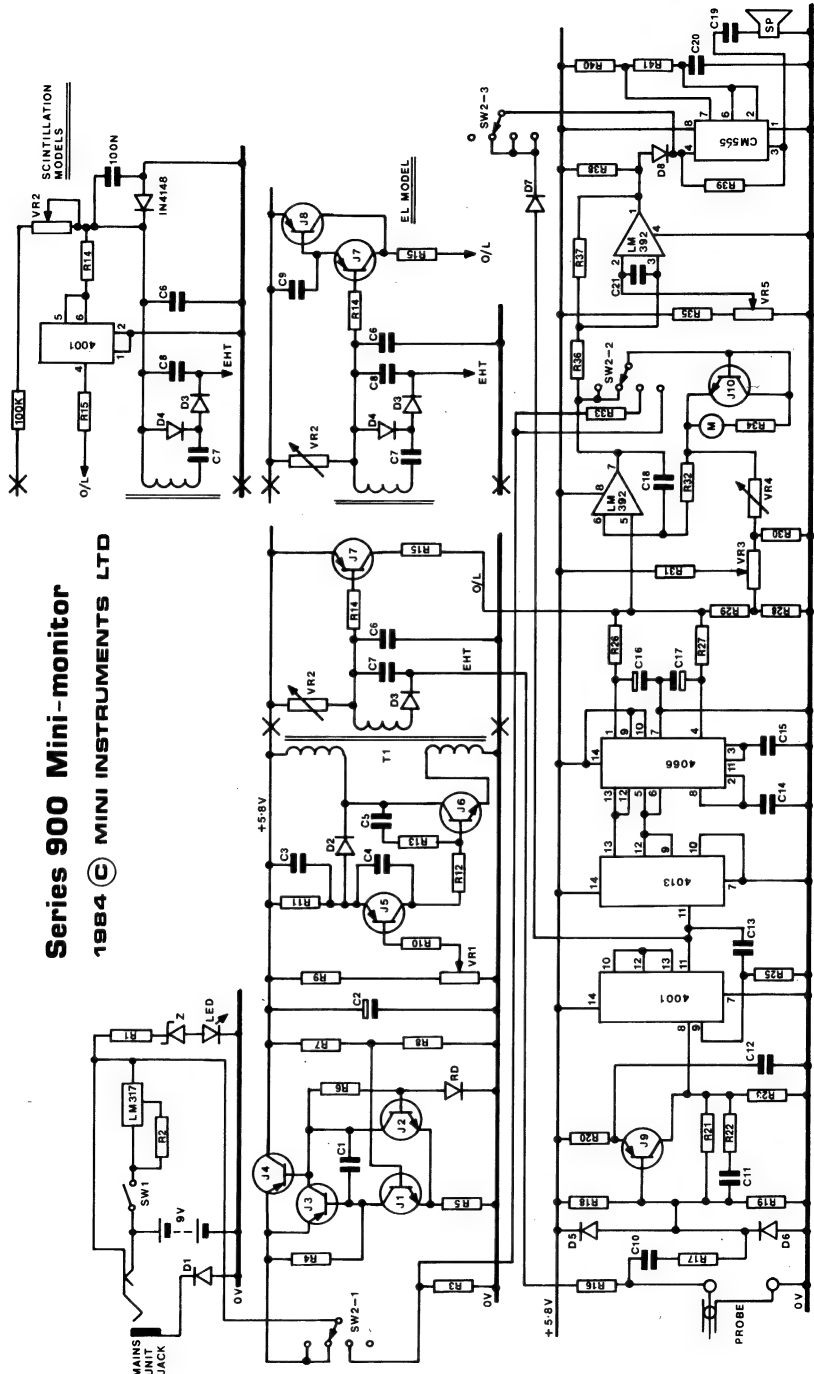
C <sub>1</sub>	4n7F	Ceramic	
C <sub>2</sub>	470μF	Electrolytic	16 volt
C <sub>3</sub>	100nF	Foil	
C <sub>4</sub>	100pF	Foil	
C <sub>5</sub>	220pF	Ceramic	
C <sub>6</sub>	2μ2	Tantalum	bead
C <sub>7</sub>	10nF	Ceramic	1000 volt
C <sub>8</sub>	6n8F	Ceramic	2000 volt
C <sub>9</sub>	100pF	Ceramic	
C <sub>10</sub>	1nF	Ceramic	2000 volt
C <sub>11</sub>	47nF	Ceramic	
C <sub>12</sub>	4n7F	Ceramic	
C <sub>13</sub>	1nF	Poly	5%
C <sub>14</sub> , C <sub>15</sub> , C <sub>16</sub> , C <sub>17</sub>		See table below	
C <sub>18</sub>	4n7F	Ceramic	
C <sub>19</sub>	100nF	Ceramic	
C <sub>20</sub>	2n2F	Poly	5%
C <sub>21</sub>	4n7F	Ceramic	
Meter	500μA	Taut band moving coil	

## Model dependent component values

	R	G	D
R <sub>25</sub>	68K	240K	120K
C <sub>14</sub>	100nF	330nF	330nF
C <sub>15</sub>	2n2F	6n8F	6n8F
C <sub>16</sub>	10μF	22μF	10μF
C <sub>17</sub>	2μ2F	2μ2F	4μ7F
	<u>E, S, SL, X</u>	<u>EP15</u>	<u>EL</u>
R <sub>16</sub>	1M	1M	4M7
R <sub>22</sub>	39K	39K	none
R <sub>25</sub>	120K	390K	390K
C <sub>6</sub>	2μ2F	2μ2F	470
C <sub>14</sub>	220nF	470nF	470nF
C <sub>15</sub>	4n7F	10nF	10nF
C <sub>17</sub>	1μF	22μ2F	2μ2F
VR <sub>2</sub>	100K	100K	4M7

# Series 900 Mini-monitor

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# Model dependent component values

	G-M models			Scintillation models		
	E,S,X	EL	R	G	pre-amp	no pre-amp
R <sub>18</sub>	1M	4M7	1M	1M	100k	100k
R <sub>22</sub>	39K	none	39K	39K	39K	replaced
R <sub>25</sub>	120K	390K	68K	240K	68K	with 15pF 68K
C <sub>6</sub>	2μ2F	47nF	2μ2F	2μ2F	100nF	100nF
C <sub>14</sub>	220nF	470nF	100nF	330nF	100nF	100nF
C <sub>15</sub>	4n7F	10nF	2n2F	6n8F	2n2F	2n2F
C <sub>16</sub>	4μ7F	4μ7F	10μF	22μF	4μ7F	4μ7F
C <sub>17</sub>	1μF	2μ2F	2μ2F	2μ2F	1μF	1μF
VR <sub>2</sub>	100K	4M7	100K	100K	220K	220K

100nF  
2% Foil  
2% Foil  
Elect.  
Elect.

Series 900 Radiation Monitors

Revised circuit board, models 900 'R' 'G' & 'D' (ALSO: E, SCINT., ETC.)

This monitor incorporates a revised circuit board. Please substitute the following information for the original text shown in the manual.

### 5.2 Meter zero adjustment

The mechanical zero is set on the meter barrel and any adjustment must be made with the monitor switched off. The pointer must rest at approximately 1mm below the scale zero. With the monitor switched on the electrical zero control R34 is now adjusted to bring the pointer back to the scale zero. Owing to background radiation it must be adjusted with the G-M tube disconnected. Allow several minutes for the meter to settle before making the adjustment.

### 5.3 Meter calibration

The calibration potentiometer R31 is situated at the bottom centre of the printed circuit board. To recalibrate inject square pulses of a few volts via a 100pF(2kV) capacitor into the G-M tube input pin (junction of R22/C14). The pulse repetition rate will need to be corrected to allow for paralysis time correction built into the scale. The table below relates the scale with the pulse repetition frequency (PRF).

Table (unchanged)

### 5.4 HV supply

The detector HV supply can be varied from approximately 300 to 650 volts. The control for adjusting the HV is R18. Anti-clockwise rotation increases the potential. The voltage is best measured using a high resistance meter, at least 20kohm/V, connected between the junction of R22/C11 and 0V. The required operating voltage is 450V for the model 'G' and 550V for models 'R' and 'D'.

### 5.5 Overload setting

An overload circuit ensures that the meter pointer remains over maximum deflection for radiation intensities exceeding many times the maximum scale reading. The adjustment depends on the HV setting and G-M tube and must be done whenever either is changed. The control for setting the overload alarm point is the potentiometer R20.

To adjust the alarm set the function switch to the 'speaker off' position and turn the control fully anti-clockwise. Using a strong source to send the meter well over the maximum scale mark, adjust the control to sound the alarm. Check that the alarm stops sounding when the source is moved to a position where the reading is equal to the maximum scale mark on the meter. If necessary re-adjust the control until this condition is met. In case of difficulty the company should be consulted.

\* This entire section is revised.

## 7. CIRCUIT DESCRIPTION

The circuit diagram is given at the end of the manual. The circuit operation is as follows:-

(a) **Battery input stabilising circuit** The line voltage of the monitor is  $5.8 \pm 0.2$  volts and is set by the reference diode D4. IC2 is the comparator coupled to the series control TR1.

(b) **HV Converter** Transistor TR4 coupled to the transformer T1 forms the flyback converter circuit. IC3 forms a gated oscillator to provide the drive for TR3 and TR4. The output voltage is stabilised by negative feedback via a resistive divider to a gate in IC3 which controls the oscillator frequency. Adjustment to the divider and hence the HV level is provided by R18. The waveform across the secondary winding of T1 is half wave rectified to provide the detector voltage. Voltage doubling is used for the scintillation monitors and detectors operating above 600V.

(c) **Input amplifier** TR5 and TR6 form an amplifier with a gain determined by feedback. It reverses the phase of the input pulse and supplies a positive signal to a monostable circuit IC4b which determines the paralysis time. The input requires negative pulses exceeding 100 mV into approximately 3000 ohms.

(d) **Ratemeter circuit** Two analogue outputs from IC5 are combined to give a signal nearly proportional to the log of the input pulse rate. This output is applied to an operational amplifier IC6a which drives the meter. The potentiometer R31 sets the meter scale and R34 the meter zero.

(e) **Audio output** The speaker derives its power from IC7 which produces a 300 $\mu$ s pulse when triggered by the monostable (IC4b). This connection is switched at the front panel to suppress the pulse output. A similar but unswitched connection from the comparator sets off the timer to give the alarm.

(f) **Comparator** The comparator IC6b compares the potential on the set alarm control with an output from the meter amplifier IC6a. If the latter is greater the comparator trips and sets off the timer. A little hysteresis is applied to smooth out the random nature of the input.

(g) **Overscale circuit** Excess current drawn through the probe when in a radiation flux exceeding many times the scale limit causes the comparator formed by IC3d to trip thus maintaining the deflection of the meter. The potentiometer R20 sets the limit when this occurs.

## 9. COMPONENT LIST & CIRCUIT DIAGRAM

### RESISTORS

ALL RESISTOR MFR4 EXCEPT WHERE STATED OTHERWISE

R1	330R	R25	4K7
R2	27R	R26	39k
R3	390R	R27	22K
R4	47K	R28	SEE TABLE BELOW
R5	6K8	R29	1M0
R6	82K	R30	1M0
R7	22K	R31	2K0 POTENTIOMETER
R8	4M7	R32	7K5
R9	100K	R33	180R
R10	470R	R34	100K POTENTIOMETER
R11	330K	R35	180R
R12	68R	R36	82K
R13	180R	R37	10K
R14	10R	R38	10K
R15	400M THICK FILM	R39	24K
R16	220K	R40	10K
R17	1M8	R41	330K
R18	2M0 POTENTIOMETER	R42	22K POTENTIOMETER
R19	SEE TABLE BELOW	R43	4M7
R20	220K POTENTIOMETER	R44	47K
R21	1M0	R45	47K
R22	1M0 MFR5	R46	10K
R23	3K3	R47	120K
R24	10K		

### CAPACITORS

C1	100nF CERAMIC	C14	1n0F CERAMIC 2KV
C2	47nF CERAMIC	C15	4n7F CERAMIC
C3	470μF ELECTROLYTIC	C16	1n0F POLYSTYRENE
C4	100nF CERAMIC	C17	SEE TABLE BELOW
C5	22pF CERAMIC	C18	SEE TABLE BELOW
C6	220pF POLYSTYRENE	C19	SEE TABLE BELOW
C7	4n7F CERAMIC	C20	SEE TABLE BELOW
C8	6n8F CERAMIC 2KV	C21	100nF CERAMIC
C9	NOT FITTED	C22	4n7F CERAMIC
C10	NOT FITTED	C23	100nF CERAMIC
C11	6n8F CERAMIC 2KV	C24	4n7F CERAMIC
C12	100nF CERAMIC	C25	100nF CERAMIC
C13	100μF ELECTROLYTIC	C26	2n2F POLYSTYRENE

# DIODES

D1	IN4001	IC1	LM317
D2	BZX83 C9V1	IC2	7611DCPA
D3	IM0 5120	IC3	HEF4001
D4	ICL8069	IC4	HEF4013
D5,6,10-15	IN4148	IC5	HEF 4066
D7	BY584	IC6	LM392N
D8-9	NOT FITTED	IC7	TLC555CP

# TRANSISTORS

TR1	BC328	M1	500 $\mu$ A TAUT BAND
TR2,5,6	BC548B		MOVING COIL
TR3	BC558		
TR4	BC639		

# MODEL DEPENDANT COMPONENT VALUES

	R	G	D
R19	47K	47K	100K
R28	68K	300K	120K
C17	POLYSTYRENE 2n2F	6n8F	6n8F
C18	POLYESTER 100nF	330nF	330nF
C19	ELECTROLYTIC 10 $\mu$ F	22 $\mu$ F	10 $\mu$ F
C20	ELECTROLYTIC 2 $\mu$ 2F	2 $\mu$ 2F	4 $\mu$ 7F

# SCINTILLATION:

100K  
68K

2n2F 1% polystyrene  
100nF 5% poly styrene  
4 $\mu$ 7F electrolytic  
1 $\mu$ F electrolytic

R17: 820K

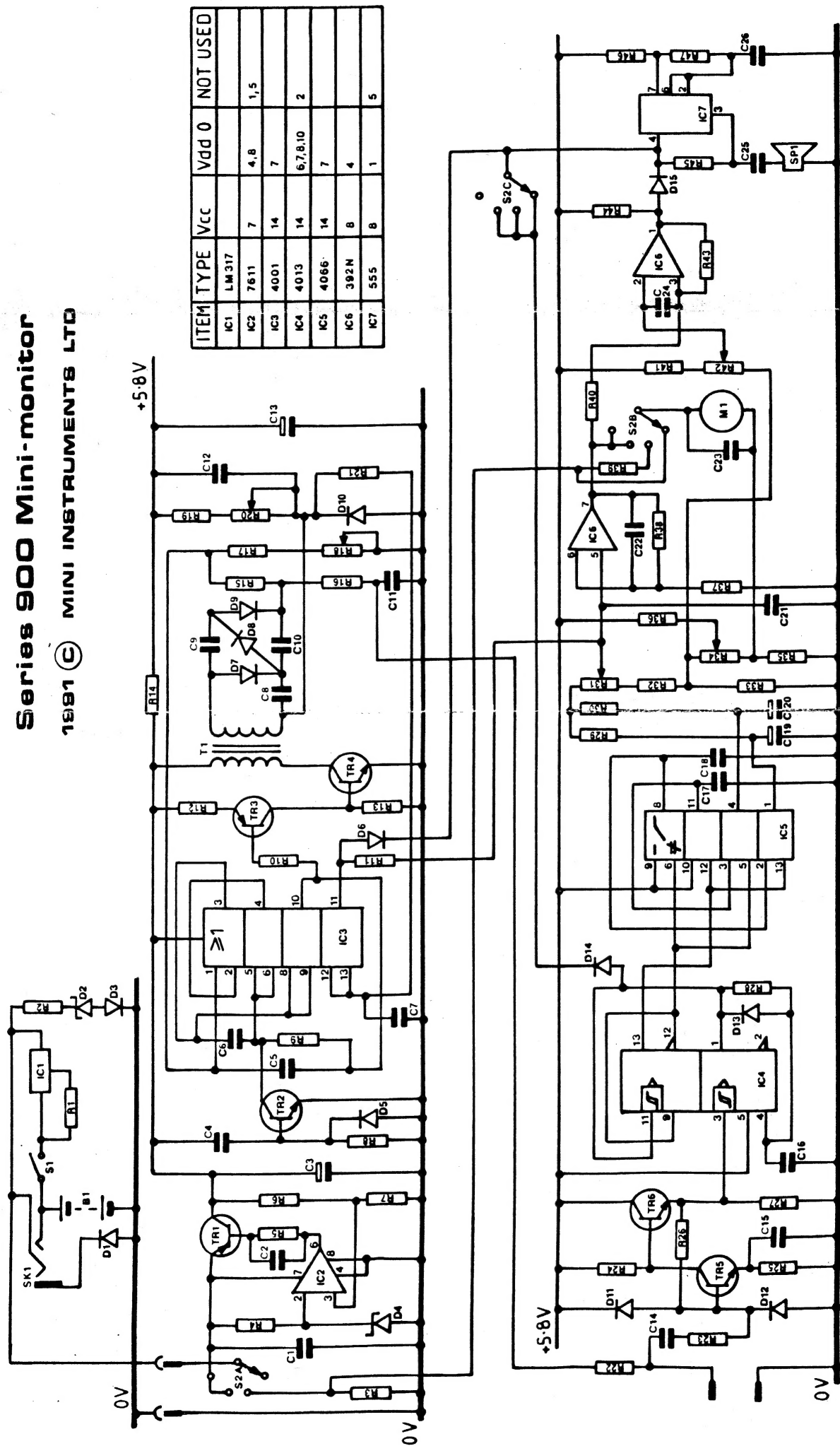
R22: ~~100K~~ 100K

c8: 10nF 1kV ceramic  
& c9 & c10 (ceramic)

D8-9: BY584

R26 is increased to  
180K $\Omega$  for scint/Multi  
probes with no pre-amplifier

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ITEM	TYPE	Vcc	Vdd 0	NOT USED
IC1	LM317			
IC2	7611	7	4,8	1,5
IC3	4001	14	7	
IC4	4013	14	6,7,8,10	2
IC5	4066	14	7	
IC6	392N	8	4	
IC7	555	8	1	5

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Address of factory  
(or address of factories) for  
which the instrument was provided

Serial number

42091

MS. A

$$\text{Calibration Factor} = \frac{\text{Applied dose rate } \mu\text{Sv/h}^{-1}}{\text{Instrument reading } \mu\text{Sv/h}^{-1}}$$

The test and/or calibration carried out on this instrument establishes a performance correct to its type. Subject to limitations of the instrument, its intended use may require other tests or calibrations. Your local qualified person should be consulted.